# PATENT ABSTRACTS OF JAPAN

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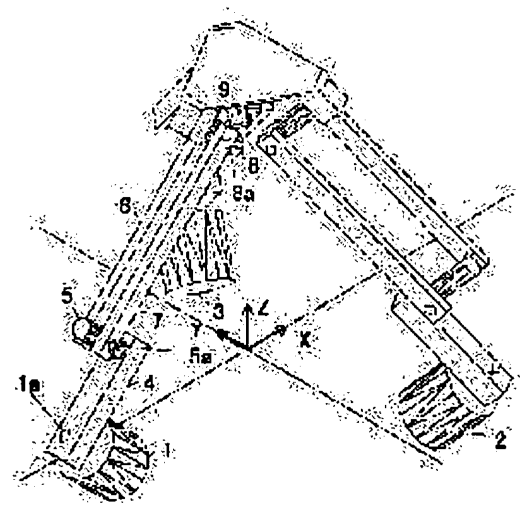
(54) PARALLEL LINK MECHANISM

(57)Abstract:

PROBLEM TO BE SOLVED: To eliminate an uncontrollable specific point by fixing the axial direction of an output point in case of three degrees of freedom, and to expand an operation range by connecting rotary shafts of a rotary support shaft to a movable support shaft so as to become parallel and connecting the movable support shaft to a movable base so that the respective shafts can only freely rotate.



SOLUTION: A rotary support shaft 5 is held axially parallel to a driving shaft 1a through a rotary arm 4 in a rotational pair state to a driving system numerically controlling to a turning angle introduced by a computer by a driving motor 1, a driving motor 2 and a driving motor 3 having respectively unparallel axial angles. Next, one ends of a parallel link 6 and a parallel link 7 are connected in a rotational pair at a right angle to the rotary support shaft 5 through a link pin 5a, and the other ends of the parallel link 6 and the parallel link 7 are similarly connected in a rotational pair at a right angle to a movable support shaft 8 through a link pin 8a to the movable support shaft 8. The movable support shaft 8 is connected axially parallel to respective driving shafts 1a in a rotational pair to a movable base 9.

LEGAL STATUS

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CLAIMS

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[Claim(s)]
[Claim 1] The parallel link mechanism which connected the revolution support shaft 5 and the migration support shaft 8 turning around the periphery side top which is not parallel to each other respectively so that each revolving shaft might grow into parallel by the 2-dimensional parallel link, and connected [ the revolution ] each shaft to the migration base 9 for the migration support shaft 8 free.

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[Translation done.]

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## DETAILED DESCRIPTION

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[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the parallel link mechanism for realizing actuation on three-dimensions coordinates, such as an industrial robot, NC maneuvers machine, and a three-dimensions measuring machine, by the high speed, high degree of accuracy, and low cost.
[0002]
[Description of the Prior Art] Nonstop or many joints, and a three-dimensions measuring machine needed to operate the three-dimensions shaft or the joint uniquely with the rectangular mold, the actuator and the advice device overlapped a part for a right hand side, and inertia weight became large and, as for current and an industrial robot, had spent the great portion of need power on this. Moreover, in order to raise a precision of operation, the rigid high advice device was required and the device was high cost at the power list.
[0003] Although the parallel link mechanism had been partly taken in by NC maneuvers machine with improvement in the speed of the latest computer, there was a fault that operating range was narrow.
[0004] Moreover, in the parallel link mechanism, since it had joined with the spherical-surface bearing and the universal joint in order to secure a degree of freedom to the joint of each link, in the case of three degree of freedom, the problem was in the shaft orientations of a control point, and control of the singular point.
[0005] Since a control point was driven by the complicated device combining a straight-line advice device etc. in order to perform the shaft orientations of the outputting point in the case of three degrees of freedom, and control of the singular point, the description of a parallel link was not employed efficiently.
[0006]
[Problem(s) to be Solved by the Invention] The trouble which it is going to solve is lessening losing the singular point which fixes the shaft orientations of an outputting point by the easy device, and becomes out of control about the shaft orientations of the outputting point in the case of three degrees of freedom, and the mutual intervention of the device section, and expanding operating range.
[0007]
[Means for Solving the Problem] This invention the revolution support shaft 5 and the migration support shaft 8 turning around the periphery side top which is not parallel to each other respectively by the 2-dimensional parallel link When it connects so that each revolving shaft may grow into parallel, and only a revolution connects the migration support shaft 8 to the migration base 9 free, each shaft It is regulated, and since each migration support shaft 8 is having whenever [ axial-angle ] regulated by the one migration base 9, the migration base 9 has whenever [ different 3 axial-angle ] regulated, and has a location fixed in the triaxial direction so that the migration support shaft 8 may surely become each driving shaft 1a and parallel. The parallel link mechanism using the fault movable singularity which is one of the singular points by this being lost.
[0008]

[Example] Drawing 1 is the whole parallel link mechanism perspective view of the example of this invention equipment. To the drive system which performs numerical control to angle of rotation drawn by coordinate count by computer with the drive motor A1, drive-motor B-2, and the drive motor C3 of whenever [ axial-angle / which is not parallel respectively ] Make the revolution support shaft 5 hold in a revolute pair through a revolving arm 4 to driving shaft 1a and axial parallel, respectively. Moreover, the end of the revolution support shaft 5, the parallel link A6, and the parallel link B7 is connected to the revolution support shaft 5 and a right angle in a revolute pair through link pin 5a. Similarly, through link pin 8a, connection and the migration support shaft 8 are connected to the migration base 9 in a revolute pair, and the other end of the parallel link A6 and the parallel link B7 is connected to the migration support shaft 8 in a revolute pair at each driving shaft 1a and axial parallel at the migration support shaft 8 and a right angle.
[0009] Drawing 4 expresses superficially the link mechanism which combines in three dimensions with parallel link mechanism flat-surface simplified schematic. This explains the relation of an outline of operation. Distance about D2 and a drive motor C3 is set [ the distance of driving shaft 1a of each drive motor A1, and link pin 8a ] to D3 for the distance about D1 and drive-motor B-2. When each D1, D2, and D3 are the same as for a change ratio, the coordinate of the migration base 9 cannot perform location change on a flat surface, however when it is made to change by the ratio [three / each / D1, D2 D3, etc. ], it becomes a flat surface and vertical movement magnitude. Again The coordinate of the migration base 9 serves as the amount of impaction efficiency on a flat surface by changing the ratio of D1, D2, and D3. In the example, since each driving shaft 1a of D1, D2, and D3 is not vertical to a flat surface, D1, D2, and D3 become each driving shaft 1a and the parallel wheel base of the migration support shaft 8 in drawing 3 .
[0010] The locus which the axial intersection of the revolution support shaft 5 and link pin 5a draws from the above thing can be calculated as an operating range 14 on the three-dimensions coordinate of XYZ, when following the locus of the periphery actuation line A10 in XZ actuation range drawing of the drawing 6 parallel link mechanism, the periphery actuation line B11, and the periphery actuation line C13. The actuation zero 13 where the die length of the point dividing [ periphery 25 ] and a parallel link carries out the plot plot of the count coordinate point of having been obtained at the time of carrying out revolution arrangement 120 degrees at 45 degrees and a flat surface in 75mm, as for the inclination of 227.5mm and the revolution support shaft 5 at 3-dimensional CAD as for the locus radius which the axial intersection of the revolution support shaft 5 and link pin 5a draws as count criteria of operating range 14 expresses the location of the bottom dead point of each revolution locus. In the distance from 330mm and the actuation zero 13 of drawing 6 to the best point of operating range 14, the distance of a plotting point is [ the distance of the opposite side of the hexagon-head gestalt of drawing 5 ] the travel of angle-of-rotation 1/25rev 163mm again.
[0011] They are micro stepping motor 1600 pulse / rev about a drive motor at the above conditions. When it is what constituted control and a link from a personal computer and constituted aluminum pipe phi4xphi3 and each revolute pair from a ball bearing and torque about 7 kg-cm was proved, the distance of 100mm was able to be operated and the repeat halt location precision of less than **0.1mm and **2mm of three-dimensions position errors including backlash were able to be acquired for cycle-time 0.5 seconds. Moreover, smooth actuation was obtained in 50g weight as a load at the operating point within the limits of about 80% of the installation actuation range.
[0012] the device created in the demonstration test -- rather -- brittle -- low -- although precision, the simple load was also able to be borne and the weight of the part which moreover receives the inertia except the inertia weight of a motor whose stopping accuracy was also beyond anticipation was also able to manufacture components mark easily very few lightly with only 20g.
[0013] It was able to be made to operate, without interfering with a parallel link, even if a revolving arm rotates one time, when the include angle which a revolving arm 4 and a parallel link make in the bottom dead point of a revolving arm 4 in a demonstration test machine is in an aperture angle from parallel. thereby, from the operating range of the conventional parallel link, it was markedly alike and a large operating range was obtained.

[0014] Although considered as the arrangement which takes a large operating range in the demonstration test machine, high-degree-of-accuracy handling of the minute range is also possible by carrying out to reverse arrangement which becomes small about the driving shaft 1a section and operating range in the migration support shaft 8 and migration support shaft 8 section at the driving shaft 1a section.
[0015] It is simply available also to a three coordinate measuring machine by computing a coordinate by transposing the drive motor A1, drive-motor B-2, and the drive motor C3 of an actuator to an include-angle detection sensor.
[0016] the parallel link mechanism by this invention -- the include angle of each driving shaft 1a, arrangement, and the radius of gyration of a revolving arm 4 and the parallel link B -- specification modification is simply possible even if it makes it the equipment fabrication of various operating range, since operating range is determined by combining 7 and 8 suitably.
[0017] Since it is realizable if the revolution support shaft 5 and the migration support shaft 8 turning around the periphery side top which is not parallel to each other respectively are parallel two-dimensional, this invention can also constitute a parallel link by the configuration of a gearing, a pulley, a belt, etc. that what is necessary is just to connect so that each shaft may grow into parallel.
[0018]
[Effect of the Invention] As explained above, the parallel link mechanism of this invention is the easy structure for the three-dimensions position control of three degrees of freedom, and since it can realize high rigidity, a light weight, and low cost, utilization of it is possible for industrial robots, a machining machine, a three coordinate measuring machine, etc., and it becomes reducible [ a fast manufacturing cost ]. Moreover, since a right hand side is only the bearing of a drive motor and a link rolling mechanism, it can also perform acquiring mechanical high degree of accuracy easily, and its dependability also improves.

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[Translation done.]

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審査請求　未請求　請求項の数１　ＯＬ　（全４頁）

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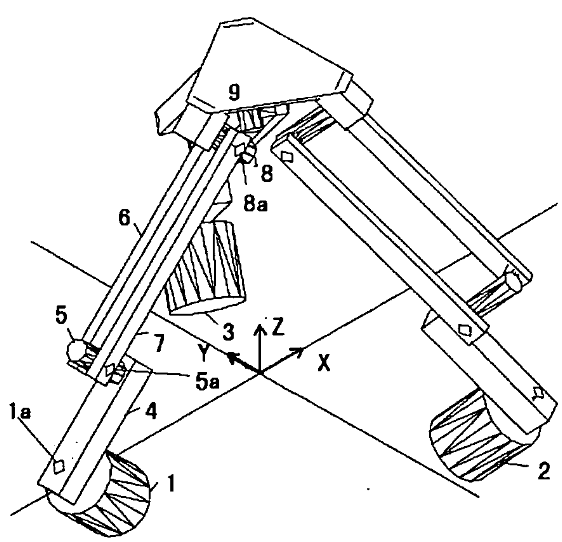
(54)【発明の名称】　パラレルリンク機構

(57)【要約】
【目的】三自由度のパラレルリンク機構の過可動特異点と動作範囲を制御するためになされたものである。
【構成】それぞれの駆動軸１ａを平行でない状態に配置し、駆動軸１ａと移動支持軸８の軸を平行に保ち移動ベース９にそれぞれの移動支持軸８を回転対偶にて固定したパラレルリンク機構。



【特許請求の範囲】

【請求項１】　それぞれお互いに平行でない円周面上を回転する回転支持軸５と移動支持軸８を二次元平行リンクにて、それぞれの回転軸が平行に成るように接続し、移動支持軸８を移動ベース９にそれぞれの軸を回転のみ自在に接続したパラレルリンク機構。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、産業用ロボット、ＮＣ工作機、三次元計測機等の三次元座標上の動作を高速、高精度、低コストで実現するためのパラレルリンク機構に関するものである。

【０００２】

【従来の技術】現在、産業用ロボットは直行又は多関節、三次元計測機は直交型で三次元軸又は関節を独自に作動させる必要があり動作部分に駆動部、案内機構が重複して慣性重量が大きくなり必要動力の大部分をこれに費やしていた。又動作精度を向上させるためには剛性の高い案内機構が必要で動力並びに機構が高コストであった。

【０００３】最近のコンピュータの高速化に伴い一部ではＮＣ工作機にパラレルリンク機構が取り入れられてきているが、動作範囲が狭いという欠点があった。

【０００４】又パラレルリンク機構において、各リンクの接合部に自由度を確保するために球面軸受け、ユニバーサルジョイントにて接合しているため３自由度の場合は制御点の軸方向、及び特異点の制御に問題があった。

【０００５】３自由度の場合の出力点の軸方向、及び特異点の制御を行うために、直線案内機構等を組み合わせて複雑な機構で制御点を駆動するため、パラレルリンクの特徴が生かされないでいた。

【０００６】

【発明が解決しようとする課題】解決しようとする問題点は、３自由度の場合の出力点の軸方向を簡単な機構にて出力点の軸方向を固定し、制御不能となる特異点を無くすることと機構部の相互干渉を少なくして動作範囲を拡大する事である。

【０００７】

【課題を解決するための手段】本発明は、それぞれお互いに平行でない円周面上を回転する回転支持軸５と移動支持軸８を二次元平行リンクにて、それぞれの回転軸が平行に成るように接続し、移動支持軸８を移動ベース９にそれぞれの軸を回転のみ自在に接続することにより、移動支持軸８は必ずそれぞれの駆動軸１ａと平行になるように規制される、又それぞれの移動支持軸８は一つの移動ベース９に軸角度を規制されているために移動ベース９は異なる３軸角度を規制され三軸方向に位置を固定される。これにより特異点の一つである過可動特異点がなくなることを利用したパラレルリンク機構。

【０００８】

【実施例】図１は、本発明装置の実施例のパラレルリンク機構の全体斜視図で、それぞれ平行でない軸角度の駆動モーターＡ１、駆動モーターＢ２及び駆動モーターＣ３にてコンピューターでの座標計算により導かれた回転角度に数値制御を行う駆動系に、それぞれ駆動軸１ａと軸平行に回転アーム４を介して回転支持軸５を回転対偶にて保持させる、又回転支持軸５と平行リンクＡ６及び平行リンクＢ７の一端をリンクピン５ａを介して回転支持軸５と直角に回転対偶にて接続、同様に移動支持軸８に平行リンクＡ６及び平行リンクＢ７の他端をリンクピン８ａを介して移動支持軸８と直角に回転対偶にて接続、そして移動支持軸８を移動ベース９にそれぞれの駆動軸１ａと軸平行に回転対偶にて接続する。

【０００９】図４は、パラレルリンク機構平面簡略図で三次元的に組み合わさっているリンク機構を平面的に表したものである。これにより概略の動作関連を説明する。それぞれの駆動モーターＡ１の駆動軸１ａとリンクピン８ａの距離をＤ１、駆動モーターＢ２についての距離をＤ２、駆動モーターＣ３についての距離をＤ３として、それぞれのＤ１，Ｄ２，Ｄ３が変化比率が同じである場合は移動ベース９の座標は平面上では位置変化はできない、ただしそれぞれのＤ１，Ｄ２，Ｄ３が等比率で変化させた場合は平面と垂直方向の移動量となる。又Ｄ１，Ｄ２，Ｄ３の比率を変化させることにより移動ベース９の座標は平面上での位置移動量となる。実施例ではＤ１，Ｄ２，Ｄ３はそれぞれの駆動軸１ａは平面に対し垂直でないのでＤ１，Ｄ２，Ｄ３は図３におけるそれぞれの駆動軸１ａと移動支持軸８の平行軸間距離となる。

【００１０】以上のことから回転支持軸５とリンクピン５ａの軸交点の描く軌跡は図６パラレルリンク機構のＸＺ作動範囲図における円周動作線Ａ１０、円周動作線Ｂ１１及び円周動作線Ｃ１３の軌跡をたどるときＸＹＺの三次元座標上で動作範囲１４として計算できる。動作範囲１４の計算基準としては回転支持軸５とリンクピン５ａの軸交点の描く軌跡半径は７５ｍｍにて円周２５分割点、平行リンクの長さは２２７．５ｍｍ、回転支持軸５の傾きは４５度及び平面に１２０度回転配置した場合のえられた計算座標点を三次元ＣＡＤにプロット作図したものである、作動原点１３はそれぞれの回転軌跡の下死点の位置を表す。図５の六角形態様の対辺の距離は３３０ｍｍ、図６の作動原点１３から動作範囲１４の最上点までの距離は１６３ｍｍ又プロット点の距離は回転角１／２５ｒｅｖの移動距離となっている。

【００１１】以上の条件にて駆動モーターをマイクロステッピングモーター１６００パルス／ｒｅｖ　トルク約７ｋｇ－ｃｍをパソコンで制御、リンクをアルミパイプφ４×φ３、各回転対偶をボールベアリングにて構成したもので実証したところ、１００ｍｍの距離を動作させサイクルタイム０．５秒、バックラッシュを含む繰り返

し停止位置精度±０．１ｍｍ以内、三次元位置誤差±２ｍｍを得ることができた。また動作点に負荷として５０ｇの重りを取り付け作動範囲の８０％程度の範囲内でスムースな動作が得られた。

【００１２】実証テスト用に作成した機構はかなり脆弱で低精度なものであるが、簡易負荷にも耐え、停止精度も予想以上であった、しかもモーターの慣性重量を除いた慣性を受ける部分の重量はわずか２０ｇと軽く部品点数も非常に少なく容易に製作可能であった。

【００１３】実証テスト機において回転アーム４の下死点において回転アーム４と平行リンクのなす角度が平行より開き角にあるとき回転アームの１回転しても平行リンクと干渉することもなく作動させることができた。これにより従来のパラレルリンクの動作範囲より格段に広い動作範囲が得られた。

【００１４】実証テスト機では、動作範囲を大きくとる配置としたが逆に駆動軸１ａ部に移動支持軸８、移動支持軸８部に駆動軸１ａ部と動作範囲を小さくなる配置を行うことにより微小範囲の高精度ハンドリングも可能である。

【００１５】駆動部の駆動モーターＡ１、駆動モーターＢ２及び駆動モーターＣ３を角度検出センサーに置き換えて座標を算出することにより簡単に三次元測定機にも利用可能である。

【００１６】本発明による、パラレルリンク機構は、それぞれの駆動軸１ａの角度と配置及び回転アーム４の回転半径と平行リンクＢ７、８を適当に組み合わせることにより動作範囲は決定するのでさまざまな動作範囲の装置製作にしても簡単に仕様変更が可能である。

【００１７】本発明は、それぞれお互いに平行でない円周面上を回転する回転支持軸５と移動支持軸８が二次元的に平行になれば実現可能なので、それぞれの軸が平行に成るように接続すればよく、歯車、プーリーとベルト等の構成により平行リンクを構成することもできる。

【００１８】

【発明の効果】以上説明したように本発明のパラレルリンク機構は、３自由度の三次元位置制御に簡単な構造で、高剛性、軽量、低コストを実現できるので、産業ロボット、工作機、三次元測定機等に利用ができ、飛躍的な製造コストの削減が可能となる。又動作部は駆動モーターとリンク回転機構のベアリングのみであるため、機械的な高精度を得ることも簡単に行え信頼性も向上する。

【図面の簡単な説明】

【図１】パラレルリンク機構の全体斜視図

【図２】パラレルリンク機構の全体上面図

【図３】パラレルリンク機構の全体正面図

【図４】パラレルリンク機構平面簡略図

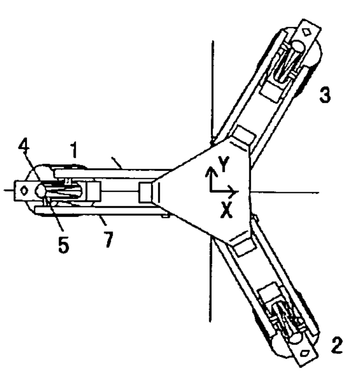
【図５】パラレルリンク機構のＸＹ作動範囲図

【図６】パラレルリンク機構のＸＺ作動範囲図

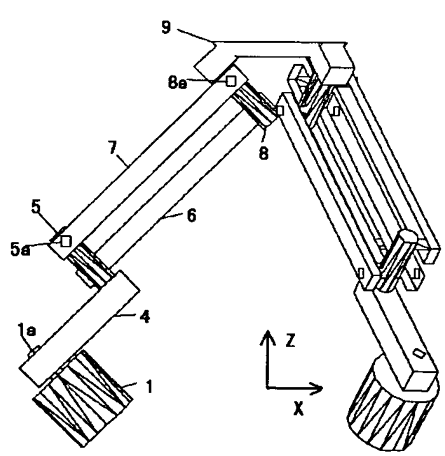
【符号の説明】

１　駆動モーターＡ
１ａ　駆動軸１ａ
２　駆動モーターＢ
３　駆動モーターＣ
４　回転アーム
５　回転支持軸
５ａ　リンクピン
６　平行リンクＡ
７　平行リンクＢ
８　移動支持軸
８ａ　リンクピン
９　移動ベース
１０　円周動作線Ａ
１１　円周動作線Ｂ
１２　円周動作線Ｃ
１３　作動原点
１４　動作範囲

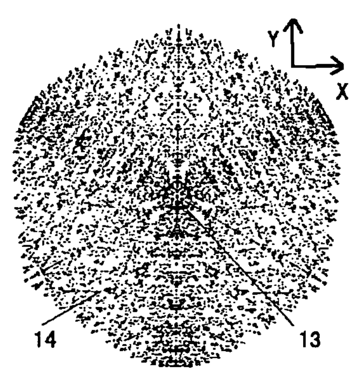
【図２】



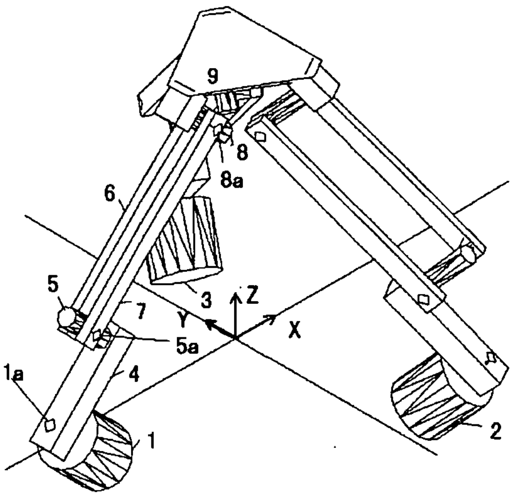

【図３】



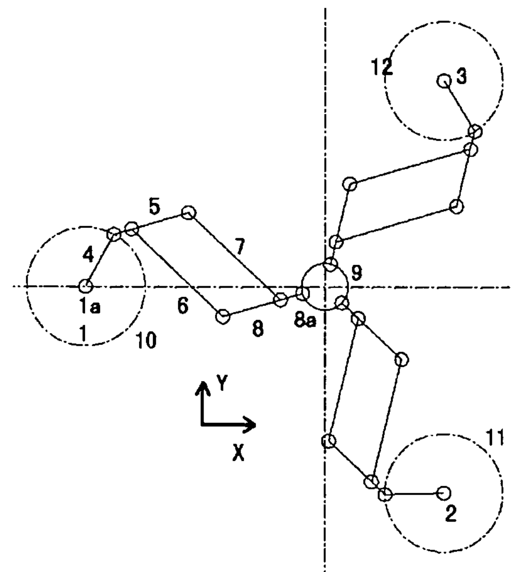

【図５】



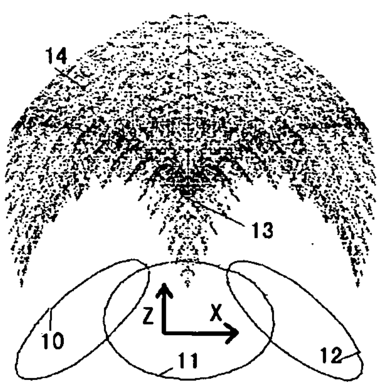
【図1】


9
8
8a
6
5
7
3
Z
Y
X
5a
1a
4
1
2

【図4】


12
3
5
7
4
9
1a
6
8
8a
1
10
Y
X
11
2

【図6】


14
13
Z
X
10
11
12